RESOURCES AT RISK: A FIRE-BASED HAZARD/RISK ASSESSMENT FOR THE BOISE NATIONAL FOREST

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ABSTRACT

On the 2.6-million-acre Boise National Forest (NF) in southwestern Idaho, wildfires have burned nearly 50 percent of the ponderosa pine forest over the last nine years. Much of this forest has burned with uncharacteristic intensity. Ponderosa pine forests are now among the most endangered and threatened ecosystems in the U. S. The historic fire regime — one marked by nonlethal surface fires that removed dense understories of saplings or pole-sized trees and increased nutrient availability — has changed. The altered fire regime now results in severe, stand-replacing fires that kill large areas of forest and return them to grass- and shrub-dominated landscapes. Preliminary analysis shows the remaining ponderosa pine on the Boise NF could be lost within the next 20 years to severe, stand-replacing wildfire.

In partnership with the University of Idaho, the Boise NF has developed a Geographic Information System (GIS)-based "hazard/risk assessment" model that estimates where the forest ecosystems are most at risk to severe, large wildfires burning in conditions outside the historical range of variability (HRV), and evaluates important resources at risk to these fires. The hazard/risk assessment links five submodels. When the submodels are linked, the assessment estimates where severe, large wildfires burning in conditions outside HRV would severely deplete late-successional habitat needed by old-growth-dependent and other wildlife species, accelerate naturally-high levels of erosion and sedimentation, and increase the likelihood that identified fish populations will not persist.

The hazard/risk assessment is most appropriately used to approximate the relative size and extent of the fire-based ecosystem problem on the Forest — the result of excluding fire from fire-adapted ponderosa pine ecosystems. It is intended to "nest" between the large-scale analysis undertaken as part of the Upper Columbia River Basin assessment, and the site-specific evaluation performed for landscape- and project-level analysis.

INTRODUCTION

The Boise NF has an especially acute focus on forest ecosystem health. Its ponderosa pine forests are among the endangered and threatened ecosystems in the U. S. (Noss et al, 1995).

Historically maintained by frequent, low-intensity fire, the 1.1-million acres of ponderosa pine forests encompassed by the Boise NF have been altered by decades of fire suppression, grazing and logging that removed fire-adapted species. In these and other areas throughout the Interior West, ponderosa pine forests are now dominated by dense stands of Douglas-fir and other fire-sensitive species (Noss et al, 1995).

When wildfires now occur in ponderosa pine forests with altered fire regimes, they are more intense, severe and larger than traditionally experienced. The historic, nonlethal surface fires that removed dense understories of saplings or pole-sized trees and increased nutrient availability have been succeeded by stand-replacing fires that return large areas of forest to grass and shrubland (Crane and Fischer, 1986).

On the Boise NF, wildfires in ponderosa pine forest have been increasingly large and severe since 1986. Nearly 500,000 acres of National Forest land (about 50 percent of the Boise NF's ponderosa pine forest, and almost 20 percent of the land managed by the Forest) have burned. Many of these acres have burned

with uncharacteristic intensity. Costs to suppress these fires and undertake emergency watershed rehabilitation exceeded $100 million dollars. In many severely burned areas, soil productivity, and aquatic, wildlife and plant habitat, have been critically damaged (USDA Forest Service, Boise NF, 1992; 1995).

Preliminary analysis shows the remaining ponderosa pine forest could be fragmented, with only isolated pockets remaining, within the next 20 years (Neuenschwander, 1995). To respond to this threat to the Forest's ponderosa pine ecosystem, a Forest interdisciplinary team, working in partnership with the University of Idaho, has developed a GIS-based "hazard/risk assessment."

The assessment estimates on a relative, Forestwide basis where forest ecosystems are most at risk to severe, large wildfires burning in conditions outside the historical range of variability (HRV), and evaluates important resources at risk to these fires. The hazard/risk assessment links five submodels — forested vegetation outside HRV, fire ignition, wildlife habitat persistence, watershed hazard (erosion and sedimentation potential) and fisheries condition. When linked, these submodels estimate where severe, large wildfires burning in vegetation conditions outside HRV would alter the composition, structure and function of an ecosystem by:

- severely depleting late-successional habitat needed by old-growth-dependent and other wildlife species;
- accelerating naturally-high levels of erosion and sedimentation; and
- increasing the likelihood that identified fish populations will not persist.

DEVELOPMENT OF THE HAZARD / RISK ASSESSMENT

In developing the hazard/risk assessment, the team used GIS tools, state-of-the-art computer software designed to process and analyze spatial information.[1]

The assessment was formulated through the following steps:

1. Five GIS submodels were first created to evaluate hazards for specific resources. These submodels included forested vegetation outside HRV, fire ignition, wildlife habitat persistence, watershed hazard (erosion and sedimentation potential), and fisheries condition.

2. For each of the five submodels, a relative hazard rating, ranging from 1 (lowest) to 5 (highest), was assigned to each subwatershed. (The 378 subwatersheds on the Boise NF are drainages averaging 6,000 acres in size.)

The submodels and sample hazard ratings include:

Forested Vegetation Outside HRV

Locates areas where ponderosa pine is or once was climax or a major seral species, and examines the density of the forested vegetation in these areas (based on June, 1992 LANDSAT satellite imagery classification). Subwatersheds with moderate to high hazard (3 or higher on the 1-5 scale) for this submodel are those where 25 percent or more of the subwatershed consists of moderate or dense Douglas fir, ponderosa pine and grand fir; Douglas-fir and ponderosa pine; or Douglas-fir.

Fire Ignition

Evaluates where fires - both lightning- and human-caused - have historically started (1956-1994), based on Boise NF fire records. Subwatersheds with moderate to high risk (rated 3 or more on the 1-5 scale) are those where 4 or more fire starts have occurred in any one section (640 acres) throughout the 39-year fire history. This submodel assumes fire starts will continue to occur where they have historically.

Wildlife Habitat Persistence

Examines where large, extensive areas of late-successional forested habitat occur outside HRV, and where they would be limited following a stand-replacing fire. Subwatersheds with moderate to high hazard (rated 3 or higher on the 1-5 scale) for wildlife habitat persistence include those where 15 percent or more of the

[1]The assessment was written using ARC/INFO Version 7.03 and uses automated machine language (AML) to process data in the GRID, ACRPLOT, ARCEDIT and TABLES modules. Most of the analysis was performed using rasterized data in the GRID module, ARCPLOT for graphic output, and TABLES for reports. Data was analyzed and displayed on a system that included an IBM RISC-6000 "390" server and AIX 3.2.5 operating system on a Thinwire Ethernet local area network (LAN).

subwatershed would remain as late-successional habitat following wildfire, with only one (or no) patch at least 350 acres in size. (Low-elevation subwatersheds which primarily consist of grass, brush and shrublands are not included in this analysis.)

Wildfire burning in an altered regime in dense, late-successional habitat could alter the successional pathway, changing the current vegetation structure to shrub/brushfields and displacing or eliminating populations dependent on the late-successional habitat for several hundred years. Large, severe wildfire could also result in ecosystem simplification, with greater landscape homogeneity, and loss of biodiversity (including genetic diversity) [Neuenschwander, 1995].

Watershed Hazard (Erosion and Sedimentation Potential)

Evaluates potential natural sediment yield, as determined from landtypes (areas with similar soils and landforms, and therefore similar hazards and capabilities). Moderate to high subwatersheds (rated 3 or higher on the 1-5 scale) for watershed hazard are those with an average potential natural sediment yield of 35 tons/square mile/year or more.

Fisheries Condition

Selects spring/summer chinook salmon and bull trout as indicator species, because in Idaho chinook have been listed as "endangered," and bull trout as "warranted but deferred," under the Endangered Species Act of 1973. For chinook salmon, moderate and high hazard subwatersheds (rated 3 or higher on the 1-5 scale) are those where spawning and rearing habitat for chinook salmon exists. For bull trout, moderate and high hazard subwatersheds are those where within strong regional populations, there is risk that local populations will not persist: those populations relatively lower in abundance, smaller in areal extent, isolated from other populations and therefore less likely to recover from uncharacteristic fire.

The fisheries condition submodel assumes that large wildfires burning in conditions outside HRV would lead to environmental disturbances (floods, etc.) that decrease the likelihood of persistence for those fish populations low in abundance (chinook salmon) or important to regional populations (local bull trout populations).

3. An overall "high risk" rating was assigned to a subwatershed if it received moderate ("3") or higher hazard ratings from ALL FIVE submodels.

4. A watershed was rated as "high risk" if at least ONE subwatershed within it received an overall high risk rating. (The 82 watersheds on the Boise NF are larger drainages, about 30,000 acres in size, which consist of several subwatersheds.) This assignment reflects the Forest's observation that the recent uncharacteristic wildfires are burning across vast landscapes and entire watersheds.

RESULTS

The hazard/risk assessment was designed in part to answer two questions:

Where are forest ecosystems most at risk to severe, large wildfires burning outside HRV?

- Based on current information and analysis, the forest ecosystems most at risk to severe, large wildfires burning outside HRV include large areas of moderate and dense forest where ponderosa pine is or was a major seral species, and where moderate to high numbers of fires have occurred. By linking the fire ignition submodel (which can identify those subwatersheds with moderate to high levels of fire ignition), with the forested vegetation outside HRV submodel (which can identify those subwatersheds with moderate to high hazard for forested vegetation outside HRV), the assessment estimates that up to 152 subwatersheds (total of 1,196,781 acres) are those most at risk to severe, large wildfire burning in vegetation conditions outside HRV.

What important resources are at risk to these severe wildfires?

- To determine what important resources are at risk to these fires, the hazard/risk assessment estimated where severe, large wildfires burning in vegetation conditions outside HRV would affect specific wildlife, watershed and fisheries resources. By linking all five submodels included in the assessment, analysis indicates that in 20 watersheds (total of 610,389 acres), all of these important resources could be affected by severe, large wildfires burning in vegetation conditions outside HRV.

APPLICATIONS AND CONCLUSIONS

The hazard/risk assessment is designed to evaluate the relative size and extent of the Boise NF's challenge in managing sustainable, resilient and resistant ponde-

rosa pine ecosystems. It also tells land managers where to "go look closer" -- where to begin evaluating site-specific conditions at a finer scale, where to begin determining a "desired future condition" for a landscape at risk, and finally, where and what specific projects might be designed and undertaken, if needed, to begin restoring sustainable ecosystem conditions across the landscape.

The assessment is intended to "nest" between the large-scale analysis undertaken as part of the Upper Columbia River Basin assessment, and the more site-specific evaluation performed for watershed- and landscape- or project-level analyses. The assessment is compatible with the Forest Service National Hierarchical Framework of Ecological Units. The Forest lies in Section M332A (Idaho Batholith) of Province M332 (Middle Rocky Mountain Steppe - Coniferous Forest - Alpine Meadow) [McNab et al, 1994]. Habitat types developed as a basis for the wildlife persistence model were in turn developed based on "section" information established by the Upper Columbia River Basin assessment. Information from the hazard/risk assessment can thus be aggregated to ecological "sections" at a larger scale.

Because the assessment was developed to analyze conditions on a Forestwide basis, it should not be used for more site-specific watershed- and landscape- or project-level work without further evaluation and refinement.

The hazard/risk assessment represents an important addition to the "analysis toolbox" available to today's land managers. It recognizes the potential for large, severe wildfires burning with altered fire regimes to damage important resources, and to substantially interrupt successional pathways historically not experienced on the large scale we see today. Because it focuses on potential effects to fisheries populations, late-successional wildlife habitat, and sedimentation, the hazard/risk assessment highlights the consequences of severe, stand-replacing fire burning outside historical patterns to disturb the dynamics of an entire ecosystem.

Given the potential loss of ponderosa pine-dominated forests on the Boise NF in the next 20 years, the hazard/risk assessment can be a primary tool for prioritizing areas most at risk, for further evaluation. The model's structure is particularly well suited to examine situations like this in which time and resources for assessment and resolution are limited, because the assessment uses selected criteria to progressively narrow the area of consideration to one which is "do-able."

The assessment's use of GIS as the "modeling medium" is particularly appropriate in examining landscape conditions, because GIS can analyze large amounts of data and sophisticated relationships across extensive areas. Since GIS is a widely-used, state-of-the-art analysis tool, it lends itself especially well to sharing information among resource specialists from different agencies and organizations. It also facilitates expansion of the hazard/risk assessment to incorporate different ownerships and boundaries (if desired), since the challenges to ecosystem health cross jurisdictional boundaries and affect resources and resource users at many scales.

Forest scientists recognize that to restore the resistance and resilience of ecosystems with altered fire regimes, land managers must use several tools, including fire and timber harvest (Agee, 1995; Mutch, 1995). The Forest will need to conduct low-intensity fire under prescribed conditions, to begin restoring fire-dependent ecosystems, as well as to remove ground fuels and recycle nutrients; and thinning to remove less fire-resistant trees such as Douglas-fir and grand fir, while leaving the larger, fire-resistant ponderosa pine. (In today's altered landscapes, thinning is needed to remove trees from dense areas where prescribed fire alone could result in a lethal, stand-replacing wildfire.) By identifying the areas most at risk, the hazard/risk assessment takes land managers "to the ground" to look closer, with the possible outcome that some of these restoration treatments may be prescribed. If so, the hazard/risk assessment may then support the adjustment in the Forest's management course needed to incorporate different types of timber harvest, and more extensive use of prescribed fire, than traditionally undertaken.

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